Intermittent Sand Filter Systems

Recommended Standards and Guidance for
Performance, Application, Design, and Operation and Maintenance

Washington State Department of
Health

Washington State Department of Health
Office of Environmental Health & Safety
Wastewater Management Program
New Market Industrial Center
7171 Cleanwater Lane, Building 4
PO Box 47825
Olympia, Washington 98504-7825

Tel: 360.236.3062
FAX: 360.236.2261
Webpage: http://www.doh.wa.gov

Notice: This document supercedes the previous version (Effective 4/5/99). The Effective Date of this document appears in the header of each page.

Preface

The recommended standards contained in this document have been developed for statewide application. Regional differences may, however, result in application of this technology in a manner different than it is presented here. In some localities, greater allowances than those described here may reasonably be granted. In other localities, allowances that are provided for in this document may be restricted. In either setting, the local health officer has full authority in the application of this technology, consistent with Chapter 246-272 WAC and local jurisdictional rules. If any provision of these recommended standards is inconsistent with local jurisdictional rules, regulations, ordinances, policies, procedures, or practices, the local standards take precedence. Application of the recommended standards presented here is at the full discretion of the local health officer.

Local jurisdictional application of these recommended standards may be:

1) **Adopted as part of local rules, regulations or ordinances—**When the recommended standards, either as they are written or modified to more accurately reflect local conditions, are adopted as part of the local rules, their application is governed by local rule authority.

2) **Referred to as technical guidance in the application of the technology—**The recommended standards, either as they are written or modified to more accurately reflect local conditions, may be used locally as technical guidance.

Application of these recommended standards may occur in a manner that combines these two approaches. How these recommended standards are applied at the local jurisdictional level remains at the discretion of the local health officer and the local board of health.

The recommended standards presented here are provided in typical rule language to assist those local jurisdictions where adoption in local rules is the preferred option. Other information and guidance is presented in text boxes with a modified font style to easily distinguish it from the recommended standards.

Summary of Significant Changes –Effective July 1, 2000

Section 3.7 Disposal Component: Amended section regarding disposal component and drainfield sizing following intermittent sand filters to be consistent with references to "Recommended Standards and Guidance for Effluent Quality-Based Drainfields."

Section 4.2.1 Media Specification: Sand media specification amendments to allow the use of a new Course Sand Media Specification.

Section 4.4 Minimum Dosing Frequency: A new section added that specifies the required dosing frequency (minimum 18 times/day) with use of the Coarse Sand Media.

Appendix A. Intermittent Sand Filter Media

1. **Coarse Filter Media Specification:** The new Coarse Sand Media specification is provided.

2. **ASTM C-33 Specification:** The C-33 particle size distribution is changed to the current ASTM C-33-99a, Specification for Fine Aggregate.

Acknowledgements—

The Department of Health Wastewater Management Program appreciates the contribution of many persons in the on-going development, review, and up-dating of the Recommended Standards and Guidance documents. The quality of this effort is much improved by the dedication, energy, and input from these persons, including:

- Geoflow, Inc.
- Lombardi and Associates
- Orenco Systems, Inc.
- Puget Sound Water Quality Action Team
- Sun-Mar Corporation
- Washington State On-Site Sewage Association (WOSSA)
- Washington State On-Site Sewage Treatment Technical Review Committee (TRC)
- Waste Water Technologies

Table of Contents

1.0 Introduction --

Intermittent sand filters provide biodegredation or decomposition of wastewater constituents by bringing the wastewater into close contact with a well developed aerobic biological community attached to the surfaces of the filter media. This process requires unsaturated downward flow of the effluent through the filter media. The filter media may be a mineral sand or equivalently sized crushed glass meeting one of the media specifications listed in Appendix A. The media is contained in a watertight vessel either below the surface of the ground or wholly or partially elevated in a containment vessel. Proper function requires that influent to the filter be distributed over the media in controlled, uniform doses. In order to achieve accurate dosing, these systems require a timer controlled pump with associated pump chambers, electrical components and distribution network, with a minimum of 4 doses per day spread evenly over a 24 hour period. The effluent is collected in the bottom of the filter and discharged either by gravity or pressure to a suitable disposal component, usually a conventional sub-surface drainfield.

This technology is used on sites with shallow soil conditions where treatment must be accomplished before disposal. Sand filter effluent may be discharged to as little as 12 inches of vertical separation. Intermittent sand filters are also used as part of a mitigation strategy when horizontal separations are reduced.

2.0 Performance Standards

2.1 Based on sand column studies and field testing, intermittent sand filters, when constructed and used according to these standards and guidance, is expected to perform to treatment standard 2 levels.

2.2 Effluent from an intermittent sand filter can be discharged to 12 inches of vertical separation.

3.0 Application Standards

3.1 **Listing --** Intermittent sand filters are a generic alternative technology and therefore are not listed in the department's List of Approved Systems and Products as a proprietary system, but may be permitted by local health officers as there is a DOH Standard and Guidance document available.

3.2 Permitting

3.2.1 Installation, and if required, operational, permits must be obtained from the appropriate local health officer prior to installation and use.

Figure 1-Typical Layout of an Intermittent Sand Filter

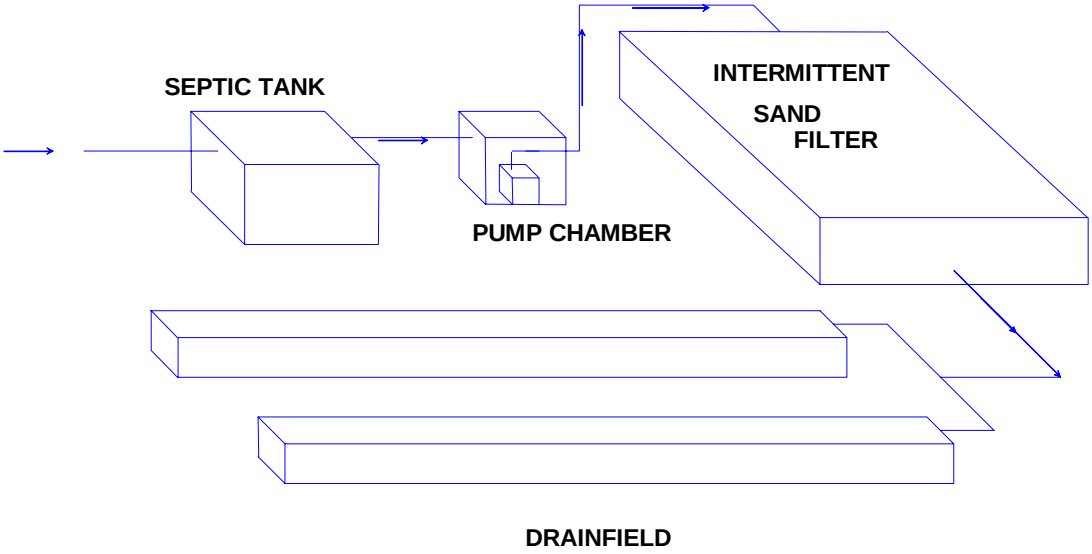


Figure 2-Typical Intermittent Sand Filter, Cross Section

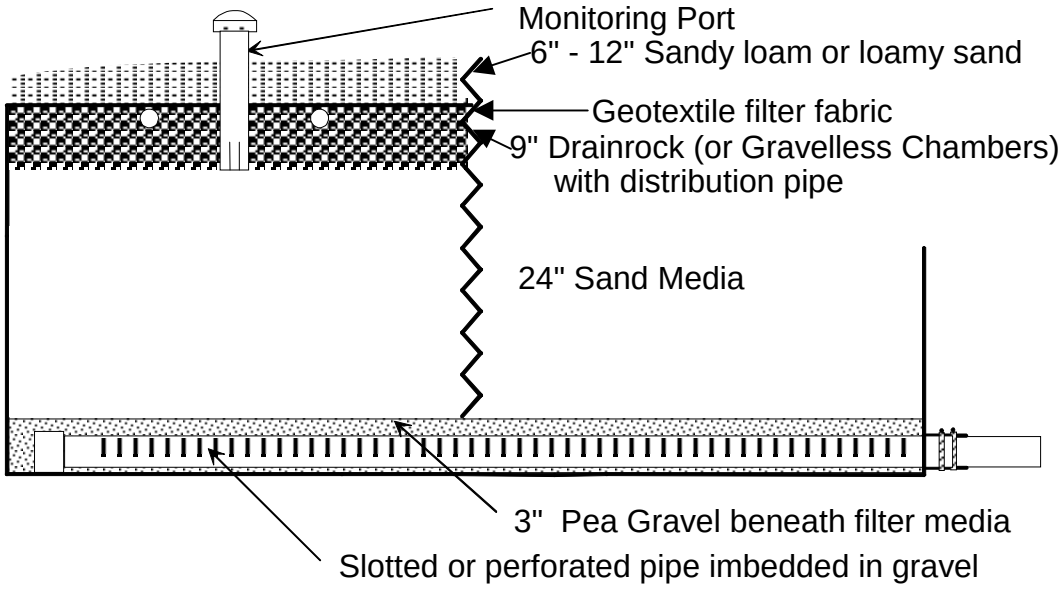
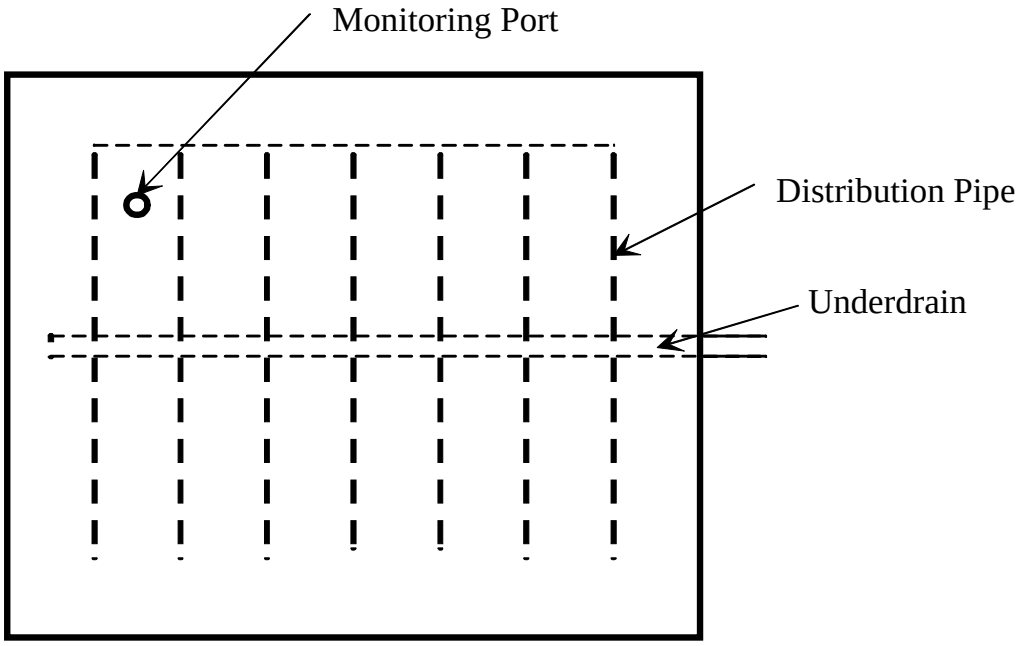


Figure 3-Typical Intermittent Sand Filter, Top View



3.3 Influent Characteristics

3.3.1 Residential Wastewater: Intermittent sand filters are designed for treating residential strength wastewater. The wastewater applied to the intermittent sand filter must not be higher in strength than 220 mg/l BOD_5 or 145 mg/l TSS (no TSS particles should be retained on a 1/8 inch mesh screen). Lower wastewater strengths, without increased flow rates are preferable for assuring long term operation of an intermittent sand filter system.

3.3.2 Non-Residential Wastewater: High-strength wastewater and wastewater from non-domestic sources (such as restaurants, hotels, bed and breakfast establishments, industrial and commercial wastewater sources) must be individually evaluated for treatability and degree of pretreatment required prior to an intermittent sand filter for final treatment and disposal.

3.3.3 Daily Wastewater Flow -- Design Estimates

3.3.3.1 **Residential** -- For all residential applications, a minimum wastewater design flow of at least 120 gallons/bedroom/day must be used.

3.3.3.2 **Non-Residential** -- For non-residential applications, a minimum wastewater design flow equal to 150% of the estimated daily flow should be used.

3.4 Pretreatment --

3.4.1 If the wastewater is residential sewage, settleable and floatable solid separation by a properly sized two-compartment septic tank with effluent baffle screening will suffice.

Pretreatment with some other wastewater sedimentation/initial treatment unit may be used instead of a septic tank.

3.4.2 If the wastewater is from a non-domestic source, influent to the sand filter must be equivalent to residential strength septic tank effluent.

Aerobic treatment or some other treatment process may be needed to modify the influent to the intermittent sand filter to within the range of residential septic tank effluent quality.

3.5 Location Requirements

The minimum setback requirements for intermittent sand filters are the same as required for septic tanks (WAC 262-272-09501).

3.6 Installation Issues

3.6.1 If the containment vessel is constructed of a 30 mil PVC liner, the liner must be protected by a 3 inch layer of sand beneath the liner.

3.6.2 In order to prevent differential settling when the sand filter is put into service, the filter media must have a uniform density throughout.

Uniform density may be accomplished one of two ways, depending on the moisture content of the filter media during construction. If the filter media is so dry that it can be poured (like salt or sand in an hourglass), it can simply be poured to fill the sand filter frame, then settled lightly (not compacted) to allow about 5% settling-i.e., volume reduction. However, if the filter media is moist enough that it cannot be poured, it should be placed in successive 6-inch lifts with each lift lightly settled. The intent of the light settling in both cases is eliminate large voids in the media that may collapse later when effluent is added. The light settling may be accomplished by walking on the sand, then raking (with hand tools) into the corners, along the sides, around the pumpwell (if applicable) and around monitor ports. The final bulk density should be approximately 1.3 to 1.4 g/cm^3 (81.2 to 87.4 lb/ft^3). Higher densities will reduce infiltration rates and oxygen exchange potential.

3.6.3 A geotextile filter fabric must be placed on the gravel bed. The cover soil must be capable of maintaining vegetative growth while not impeding the passage of air (sandy loam or coarser).

3.6.4 Observation ports: If the intermittent sand filter effluent exits the sand filter through the underdrain by gravity flow, two observation ports must be installed in the sand filter. One observation port must be installed to the bottom of the drainrock/top of the media interface. A second observation port must be installed to the bottom of the underdrain. In the effluent exits the sand filter through a pumpwell, the pumpwell may be used as the second observation port.

3.7 Disposal Component—

3.7.1. Direct discharge of effluent from an intermittent sand filter to surface water or upon the ground surface is prohibited by WAC 246-272-11501(2)(a). Subsurface disposal is required.

3.7.2. Drainfield design allowances vary according to treatment performance levels. Refer to the Recommended Standards and Guidance for Effluent Quality-Based Drainfields DOH ***(Effective Date: 5/15/00)***.

3.7.3. The size and design of the disposal component must be consistent with the methods and procedures indicated by WAC 246-272-09001, WAC 246-272-11001 and WAC 246-272-11501.

3.7.4. Disposal component location must meet minimum horizontal setback distances as specified by WAC 246-272-09501, and 246-272-16501.

3.7.5. Development using an intermittent sand filter must meet the minimum land area requirements specified in WAC 246-272-20501.

4.0 Design

4.1 Design Approval -- Before construction can begin, the design must be approved by local health or other appropriate jurisdiction. All site inspections before, during, and after the construction must be accomplished by local health, other appropriate jurisdiction, or by a designer or engineer appointed by the appropriate jurisdiction.

4.2 Filter Bed

4.2.1 Media Specifications -- Filter media must meet either the Coarse Sand Media or ASTM C-33 specification for particle size graduation detailed in Appendix A. Filter media used in constructing a sand filter must be accompanied with a written certification from the supplier that the sand fully conforms to one of the media specifications listed in Appendix A as determined by ASTM D136 (dry sieving) and ASTM C-117 (wet sieving).

Continued concerns have been expressed about the potential for premature clogging and/or failure of intermittent sand filters with filter media meeting the ASTM C-33 specification. ASTM C-33 particle size distribution allows the smaller sand particles to fill the voids between large particles, resulting in smaller and more convoluted pore spaces. While this condition provides a high degree of wastewater treatment, it encourages clogging of the remaining void spaces with suspended solids and biological growth, resulting in a greater chance of a restrictive biomat forming. By limiting the fine particles allowed, the new Coarse Sand Media specification is much more clog-resistant in providing the needed degree of treatment when wastewater is stronger than expected, flows are high, or other unexpected factors occur, which induces clogging. The use of the Coarse Sand Media specification, while not reducing the treatment efficiency of the sand filter, requires a lower volume, higher dosing frequency pattern to be used. The smaller the dose the better contact the wastewater will have with the bacteria and the less saturated the sand will be, allowing for sufficient diffusion of oxygen into the system. See Section 4.4 for the minimum dosing frequency required with the Coarse Sand Media used as the filter media.

4.2.2 Filter Bed Sizing

4.2.2.1 Loading Rate: The loading rate to the sand filter must not exceed 1.2 gallons/day/square foot, using appropriate daily wastewater flow design estimate.

A loading rate of 1.2 gpd/ft^2 may be too high for long term service. Recently, concern has been expressed with premature failure and/or clogging of intermittent sand filters and sand lined trench systems with ASTM C-33 sand as the filter media. Several possible contributing factors have been discussed such as; a) the ASTM C-33 specification allows for too large of a percentage of fine material (passing a No. 100 sieve) which may cause the finer material to become suspended in the filter causing an impermeable barrier near the top of the filter, b) loading rates of 1.2 gal/ft^2/day are inappropriate and should be reduced. While the Technical Review Committee recognizes the concerns, the committee feels that the data presented is inconclusive at this time. Until modifications to the standards and guidance are made, some suggestions are as follows:

A) reducing loading rates applied to intermittent sand filters and sand-lined trench systems to no more than 0.8 - 1.0 gal/ft^2/day.

B) *incorporating into the system design methods of improving oxygen exchange within the filter such as; increasing the dose frequency and/or including a venting system in the filter with vents extended to the atmosphere. Vents may need to include an odor scouring device such as an activated carbon filter installed on the end of the vent.*

C) quality control of the sand media such as frequent testing of the media to ensure that the media used consistently meets the ASTM C-33 specification.

4.2.2.2 Surface area of filter bed: The surface area must be determined by dividing the design flow estimate by the loading rate.

4.2.2.3 Depth of media: The media depth must be a minimum of 24 inches.

4.2.3 Filter bed containment: The filter bed is contained either in a flexible membrane-lined pit, or a concrete vessel. Design and construction must conform with the containment standards set forth in Appendix B.

4.3 Wastewater Distribution

4.3.1 Pressure distribution: Pressure distribution is required and must comply with the pressure distribution standards and guidance. This requirement applies to all pressure distribution related components.

4.3.2 Wastewater application to the filter bed: The wastewater must be applied to the layer of drain rock atop the filter media, or sprayed upward against the top of gravelless chambers.

4.4 Minimum Dosing Frequency: A timer-controlled system (timed-dosing) is required. The dosing frequency or dose volume is dependent on the media specification used with the sand filter. To assure that appropriate dose volumes are delivered to the sand filter, the timer must be set to dose the filter at the following minimum dosing frequency:

Media Specification	Number of Doses/Day
Coarse Sand Media ASTM C-33	18 times per day 4 times per day

With frequent dosing (e.g. greater than 12 doses/days) very little wastewater is applied to the filter at any one dose, resulting in unsaturated film-like flow. If the dose volume exceeds the water holding capacity of the filter media, the applied liquid fills the pore spaces allowing the wastewater to pass through the filter untreated. However, if the dose volume does not exceed the water holding capacity of the media, the applied wastewater will flow around the sand grains in a thin film maximizing oxygen diffusion and maximizing contact between the organics in the wastewater and the microbial growth on the media. The filter media meeting the Coarse Sand Media specification has a lower water holding capacity than the sand meeting the ASTM C-33 specification. Thus, a smaller dose volume or higher dosing frequency is required to promote the unsaturated film-like flow. Because of the larger unit wetted surface area of ASTM C-33 sand, a larger volume of wastewater may be applied at one time without exceeding its water holding capacity. The large surface allows unsaturated flow conditions to occur at a higher dose volume or lower dosing frequency.

4.5 Treated Wastewater (Filtrate) Collection and Discharge -- Filtrate may be collected and discharged from the bottom of the sand filter by either a gravity-flow underdrain, or a pumped-flow pumpwell system. When sand filters are membrane-lined, gravity flow underdrains must exit through a boot. The boot and exit pipe must be installed and tested according to the standards in Appendix C.

5.0 Operation and Maintenance

5.1 Management -- The local health officer has the authority to require that an acceptable maintenance agreement be established, and supporting documents be developed and approved by the local health officer, prior to the issuance of approvals for a proposed sand filter sewage system. It is recommended that a maintenance agreement be required when, in the opinion of the local health authority, the ongoing operation of the sand filter sewage systems is best assured by the existence of such an agreement.

5.2 User's Manual -- A user's manual for the sand filter system must be developed and / or provided by the system designer. These materials must contain the following, at a minimum:

- diagrams of the system components
- Explanation of general system function, operational expectations, owner responsibility, etc.
- Names and telephone numbers of the system designer, local health authority, component manufacturer, supplier/installer, and/or the management entity to be contacted in the event of a failure.
- Information on "Trouble-shooting" common operational problems that might occur. This information should be as detailed and complete as needed to assist the system owner to make accurate decisions about when and how to attempt corrections of operational problems, and when to call for professional assistance.
- For proprietary sand filter devices, a complete maintenance and operation document must be developed and provided by the manufacturer. This document must be made available, through the system designer, to the system owner. This document must include all the appropriate items mentioned above, plus any additional general and site-specific information useful to the system owner, and/or the maintenance person. A copy of this

document must also be provided to the local health authority, prior to the issuance of the local installation permit.

5.3 Maintenance

5.3.1 Responsibility -- For the on-site treatment and disposal system to operate properly, its various components need periodic inspection and maintenance. The maintenance is the responsibility of the homeowner, but may be best performed by experienced and qualified service providers. An Operation and Maintenance Manual must be developed and/or provided by the system designer with copies provided to the local health officer, system owner and maintenance contractor. The maintenance manual must include the following listed recommended maintenance descriptions and schedules. The local health officer may specify additional requirements.

5.3.2 Minimum Maintenance Description and Service Items

5.3.2.1 Type of use.

5.3.2.2 Age of system.

5.3.2.3 Specifications of all electrical and mechanical components installed (occasionally components other than those specified on the plans are used).

5.3.2.4 Nuisance factors, such as odors or user complaints.

5.3.2.5 Septic tank: inspect yearly for structural integrity, proper baffling, screen, ground water intrusion, and proper sizing. Inspect and clean effluent baffle screen and also pump tank as needed.

5.3.2.6 Pump chamber: clean the effluent screen (spraying with a hose is a common cleaning method), inspect and clean the pump switches and floats yearly. Pump the accumulated sludge from the bottom of the chambers, whenever the septic tank is pumped, or more often if necessary.

5.3.2.7 Pumpwell: Inspect for infiltration, structural problems and improper liquid level. Check for pump or siphon malfunctions, including problems related to dosing volume, pressurization, breakdown, clogging, burnout, or cycling. Pump the accumulated sludge from the bottom of the pumpwell, whenever the septic tank is pumped, or whenever necessary.

The liquid level at the pump start or siphon must be below the bottom of the filter media in order to prevent ponding and rise of the capillary fringe in the sand. Improper liquid level (too high in the pumpwell) can result from improper setting of the pump on float, pump burnout, disconnected electrical supply to the pump or controls, or tripped circuit breaker. In some cases the underdrain may be underdesigned and may not have the flow capacity to supply the pump at the rate that it pumps. Infiltration into the pumpwell is serious and means that the effluent is entering the pumpwell before passing through the full column of sand. Effluent that is short circuiting will not receive full sand filter treatment.

5.3.2.8 Check monitoring ports for ponding. Conditions in the monitoring ports must be observed and recorded by the service provider during all operation and maintenance activities for the intermittent sand filter and other system components. For reduced sized drainfields, these observations must be reported to the local health jurisdiction responsible for permitting the system.

5.3.2.9 Inspect and test yearly for malfunction of electrical equipment such as timers, counters, control boxes, pump switches, floats, alarm system, junction box, or other electrical components, and repair as needed. System checks should include improper setting or failure, of electrical, mechanical, or manual switches.

5.3.2.10 Mechanical malfunctions (other than those affecting sewage pumps) including problems with valves, or other mechanical or plumbing components.

5.3.2.11 Material fatigue, failure, corrosion problems, or use of improper materials, as related to construction or structural design.

5.3.2.12 Neglect or improper use, such as loading beyond the design rate, poor maintenance, or excessive weed growth.

5.3.2.13 Installation problems, such as improper location or failure to follow design.

5.3.2.14 Overflow or backup problems where sewage is involved.

5.3.2.15 Specific chemical/biological indicators, such as BOD, TSS, fecal coliforms, etc. Sampling and testing may be required by the local health officer on a case-by-case basis, depending on the nature of the problem, availability of laboratories, or other factors.

5.3.2.16 Information on the safe disposal of discarded filter media. See Appendix E.

5.4 Action Conditions -- When inspections, or any other observation, reveals either of the following listed conditions, the owner of the system must take appropriate action, according to the direction and satisfaction of the local health officer:

- drainfield system failure, as defined in WAC 246-272-01001, or
- a history of long-term, continuous and increasing ponding of wastewater within the reduced-size drainfield, which if left unaddressed, may result in untimely failure.

5.4.1 Appropriate Actions Upon Identification of Action conditions:

- repair or modification of the drainfield system,
- expansion of the drainfield system, or
- modifications or changes within the structure relative to wastewater strength or hydraulic flows

The repair or modification required may include the installation of additional drainfield to enlarge the system to 100% of the initial design size. Repair or modification is not limited to this option. Local permits must be obtained before construction begins, according to local health department requirements. Any repair or modification activity must be reported as part of the monitoring activity for the site.

Appendix A-- Filter Media Specifications

A. Particle Size Analysis

The standard method to be used for performing particle size analysis must comply with one of the following:

1. the sieve method specified in ASTM D136 and ASTM C-117
2. the method specified in Soil Survey Laboratory Methods and Procedures for Collecting Soil Samples, Soil Survey Investigation Report #1, US Department of Agriculture, 1984.

B. Intermittent Sand Filter Media

The filter media must meet either specification 1 or specification 2, below as determined by section A. Particle Size Analysis. Media may be either mineral sand or equivalently sized crushed glass.

1. Coarse Sand Media Specification

The filter media must meet items a, b, and c, below: (Source: State of Oregon On-Site Sewage Disposal Rules and the State of Wisconsin Single Pass Sand Filter Component Manual)

(a) Particle size distribution:

Sieve	**Particle Size**	**Percent Passing**
3/8 in	9.50 mm	100
No. 4	4.75 mm	95 to 100
No. 8	2.36 mm	80 to 100
No. 16	1.18 mm	45 to 85
No. 30	0.6 mm	15 to 60
No. 50	0.3 mm	3 to 15
No. 100	0.15 mm	0 to 4

(b) Effective Particle Size (D_{10}) > 0.3 mm.

(c) Uniformity Coefficient (D_{60}/ D_{10}) < 4.0

2. ASTM C-33 Specification

The filter media must meet items a, b, c, and d, below: (Source: ASTM C-33-99a, Specification for Fine Aggregate)

(a) Particle size distribution:

Sieve	**Particle Size**	**Percent Passing**
3/8 in	9.50 mm	100
No. 4	4.75 mm	95 to 100

No. 8	2.36 mm	80 to 100
No. 16	1.18 mm	50 to 85
No. 30	0.6 mm	25 to 60
No. 50	0.3 mm	5 to 30
No. 100	0.15 mm	0 to 10 (prefer <4)

[For No. 200 sieve, see note (d).]

(b) The sand must have not more than 45% passing any one sieve and retained on the next consecutive sieve of those shown above.

(c) The fineness modulus must not be less than 2.3 nor more than 3.1. The fineness modulus is calculated by adding the cumulative percentages of material in the sample retained in the sieves shown above and dividing the sum by 100.

(d) The limit for material that can pass the No. 200 sieve must not be more than 3%.

Appendix B -- Containment Vessel Standards

A. Lined Pit: when a sand filter is constructed in an excavated pit the following criteria are to be met. (Note: The majority of the following liner specification is from the State of Oregon On-Site Sewage Disposal Rules.)

1. Unsupported polyvinyl chloride (PVC) shall have the following properties:

PROPERTY	TEST METHOD	
(a) Thickness	ASTM D1593 Para 9.1.3	30 mil minimum
(b) Specific Gravity (Minimum)	ASTM D792 Method A	
(c) Minimum Tensile Properties (each direction)	ASTM D882	
(A) Breaking Factor (pounds/inch width)	Method A or B (1 inch wide)	69
(B) Elongation at Break (percent)	Method A or B	300
(C) Modulus (force) at 100% Elongation (pounds/inch width)	Method A or B	27
(d) Tear Resistance (pounds, minimum)	ASTM D1004 Die C	8
(e) Low Temperature	ASTM D1790	-20°F
(f) Dimensional Stability (each direction, percent change maximum)	ASTM D1204 212°F, 15 min.	± 5
(g) Water Extraction	ASTM D1239	-0.35% max.
(h) Volatile Loss	ASTM D1203 Method A	0.7% max.
(i) Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083	
(A) Breaking Factor		-5
(B) Elongation at Break		-20
(C) Modulus at 100% Elongation		±10
(j) Bonded Seam Strength (factory seam, breaking factor, ppi width)	ASTM D3083	55.2
(k) Hydrostatic Resistance	ASTM D751 Method A	82

2. Installation Standards:

(a) Patches, repairs and seams shall have the same physical properties as the parent material;

(b) Site considerations and preparation:

(A) The supporting surface slopes and foundation to accept the liner shall be stable and structurally sound including appropriate compaction. Particular attention shall be paid to the potential of sink hole development and differential settlement;

(B) Soil stabilizers such as cementations or chemical binding agents shall not adversely affect the membrane; cementations and chemical binding agents may be potentially abrasive agents.

(c) Only fully buried membrane liner installation shall be considered to avoid weathering;

(d) Unreinforced liners have high elongation and can conform to irregular surfaces and follow settlements within limits. Unreasonable strain reduces thickness and may reduce life expectancy by lessening the chemical resistance of the thinner (stretched) material. Every effort shall be made to minimize the strain (or elongation) anywhere in the flexible membrane liner;

(e) Construction and installation:

(A) Pit / surface / preparation:

(i) bottom of pit:

(I) covered with sand to "bed" liner, adequate in depth (minimum 3") to protect liner from puncture, or

(II) use a non-woven needle-punched synthetic geotextile fabric, in a thickness appropriate to the tasks of protecting the liner.

(III) sides of the pit smooth, free of possible puncture points.

(IV) bottom of pit (bedding layer of sand) graded to provide a sloping liner surface, from the outer edge of the filter toward the point of underdrain collection. Slope equal to 8 inches fall overall or one inch of fall per foot of run, whichever is the greatest.

(B) Climatic conditions:

(i) Temperature. The desirable temperature range for membrane installation is 42° F to 78° F. Lower or higher temperatures may have an adverse effect on transportation, storage, field handling and placement, seaming and backfilling and attaching boots and patches may be difficult. Placing liner outside the desirable temperature range shall be avoided;

(ii) Wind. Wind may have an adverse effect on liner installation such as interfering with liner placement. Mechanical damage may result. Cleanliness of areas for boot connection and patching may not be possible. Alignment of seams and cleanliness may not be possible. Placing the liner in high wind shall be avoided;

(iii) Precipitation. When field seaming is adversely affected by moisture, portable protective structures and/or other methods shall be used to maintain a dry sealing surface. Proper surface preparation for bonding boots and patches may not be possible. Seaming, patching and attaching 'boots' shall be done under dry conditions.

(C) Boots: When boots are used (required when using a gravity-flow underdrain), the boot and exit pipe must be installed with the following criteria:

(i) The system designer is to identify the use of a sand filter liner with underdrain and boot as a part of the application for on-site sewage system and provide specifications detailing design and installation requirements.

(ii) The boot is to be installed by the manufacturer or the manufacturer's representative.

(iii) The boot outlet is to be bedded in sand.

(iv) The boot is to be sized to accommodate a 4" underdrain outlet pipe.

(v) The boot is to be secured to the 4" outlet pipe with two (2) stainless steel bands and screws, and sealant strips as recommended by the manufacturer.

(vi) The underdrain is to be designed in accordance with Appendix C, Underdrains and exit the side of the liner.

(vii) An inspection port must be installed in the sewer pipe from the sand filter to the drainfield.

(viii) Sewer pipe from the sand filter to the drainfield must be ASTM 3034 ring tight.

(ix) The trench from the sand filter to the drainfield must be back-filled with a minimum 5 lineal feet clay dam to prevent the trench from acting as a conduit for ground water movement towards the drainfield.

(x) If the boot may be submerged in a seasonal high water table, performance testing of the sand filter/boot for leakage must be conducted in the following manner:

(A) Block outlet pipe;

(B) Fill underdrain gravel with water;

(C) Measure and record elevation of water through observation/inspection port;

(D) Let stand 24 hours minimum;

(E) Measure and record elevation of water through observation/inspection port;

(F) No allowable drop in the water level.

(D) Liner Placement:

(i) Size. The final cut size of the liner shall be carefully determined and ordered to generously fit the container geometry without field seaming or excess straining of the linear material;

(ii) Transportation, handling and storage. Transportation, handling and storage procedures shall be planned to prevent material damage. Material shall be stored in an secured area and protected from adverse weather;

(iii) Site inspection. A site inspection shall be carried out by local health officer, other appropriate jurisdiction or by a designer or engineer appointed by the appropriate jurisdiction. and the installer prior to liner installation to verify surface conditions, etc.;

(iv) Deployment. Panels shall be positioned to minimize handling. Seaming should not be necessary. Bridging or stressed conditions shall be avoided with proper slack allowances for shrinkage. The liner shall be secured to prevent movement and promptly backfilled;

(v) Anchoring trenches. The liner edges should be secured frequently in a backfilled trench;

(vi) Field seaming. Field seaming, if absolutely necessary, shall only be attempted when weather conditions are favorable. The contact surfaces of the materials should be clean of dirt, dust, moisture, or other foreign materials. The contact surfaces shall be aligned with sufficient overlap and bonded in accordance with the suppliers recommended procedures. Wrinkles shall be smoothed out and seams should be inspected by non-destructive testing techniques to verify their integrity. As seaming occurs during installation, the field seams shall be inspected continuously and any faulty area repaired immediately;

(vii) Field repairs. It is important that traffic on the lined area be minimized. Any necessary repairs to the liner shall be patched using the same lining material and following the recommended procedure of the supplier;

(viii) Final inspection and acceptance. Completed liner installations shall be visually checked for punctures, rips, tears and seam discontinuities before placement of any backfill. At this time the installer shall also manually check all factory and field seams with an appropriate tool. In lieu of or in addition to manual checking of seams by the installer, either of the following tests may be performed;

(I) Wet Test: The lined basin shall be flooded to the one (1) foot level with water after inlets and outlets have been plugged. There shall not be any loss of water in a 25-hour test period.

(II) Air Lance Test: Check all bonded seams using a minimum 50 PSI (gauge) air supply directed through a 3/16 inch (typical) nozzle, held not more than 2 inches from the seam edge and directed at the seam edge. Riffles indicate unbonded areas within the seam, or other undesirable seam construction.

B. Concrete Containment Vessel: to be designed and/or approved by a qualified professional engineer if the following conditions are not met.

1. Above ground tank.

   a. Walls

      (1) at least 6 inches thick

      (2) 4 feet or less in height

      (3) rebar reinforcement: 3/8 inch diameter rebar on 2-foot centers horizontally and vertically, with continuous lengths wrapped around the corners.

   b. Floor

      (1) at least 3 1/2 inches thick

      (2) reinforced with steel mesh (CRSI standard #6-1010) to prevent cracking and to maintain water-tightness

   c. Tank is to be designed, constructed, and sealed to be water-tight.

2. Below ground tank.

   Any below-ground concrete tank must be water-tight. The design of any such tank is to be approved by a qualified professional engineer and, where required by local and/or state regulation, the local health officer.

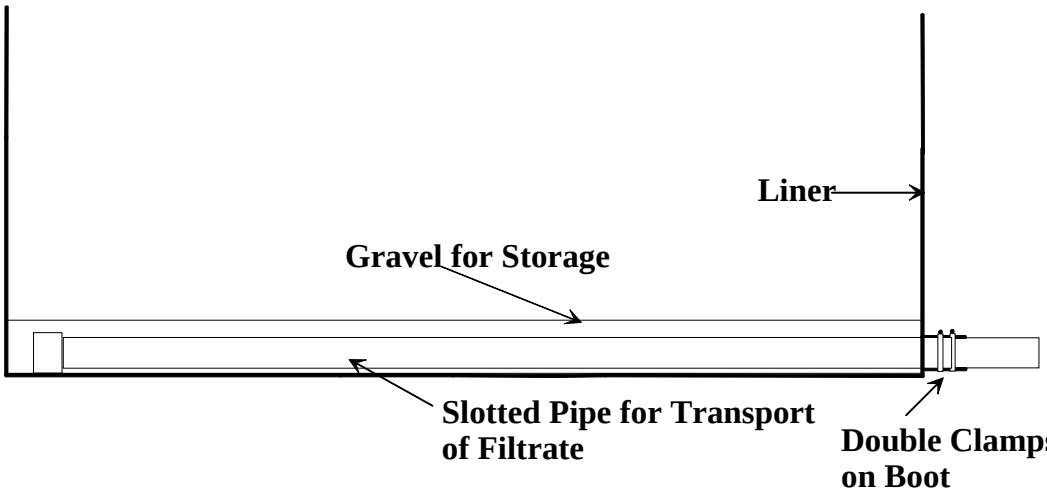
Appendix C -- Underdrains

A. For Concrete Tanks or Synthetic Membrane-Lined Pits: Either gravity underdrains or pumpwells may be used.

B. Underdrains: Underdrains must be designed with sufficient void storage volume to provide for a single drainfield dose with reserve capacity to maintain unsaturated filter media above the underdrain system. Collection pipe must be sized of sufficient size, with adequate perforations, or slots so that filtrate can flow from the void storage space into the collection pipe rapidly enough to maintain unsaturated filter media above the underdrain system. May be designed in a variety of ways.

One possible way is:

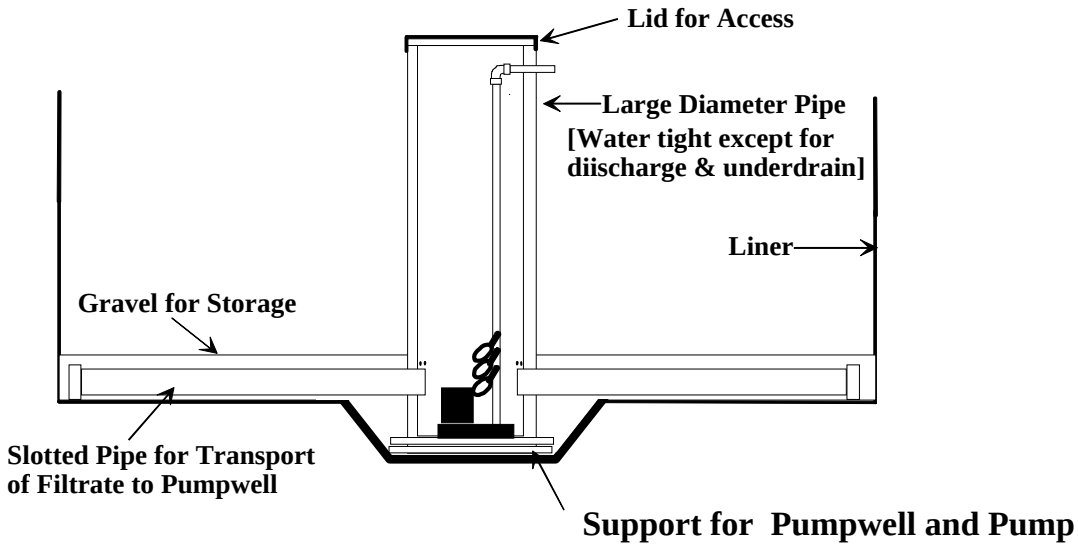
Place a 3 inch layer of pea gravel over a 6 inch layer of 3/4 to 2-1/2 inch gravel containing the underdrain collection pipe. The purpose of the pea gravel is to restrict the migration of sand into the gravel and pipe in the underdrain. The gravel surrounding the slotted or perforated pipe should be sized larger than the slots or perforations to prevent migration of gravel into the pipe. See Figure 1. For the purpose of calculating void storage space in the medium gravel (3/4 to 2-1/2 inch), 3.0 gallons per cubic foot may be used assuming 40% void space per cubic foot.



Typical Cross-section Of An Intermittent Sand Filter Underdrain

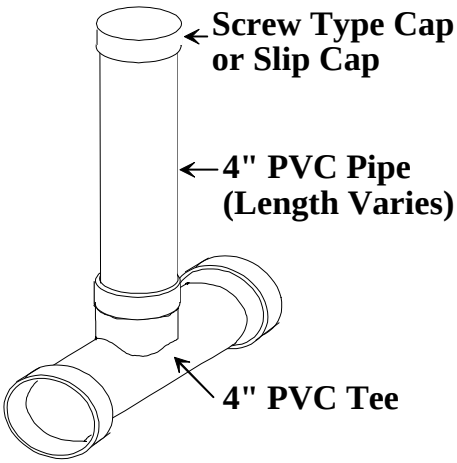
C. Pumpwells: are located within the filter. Filtrate is collected in a underdrain system underlying the filter media and is discharged directly into the pumpwell.

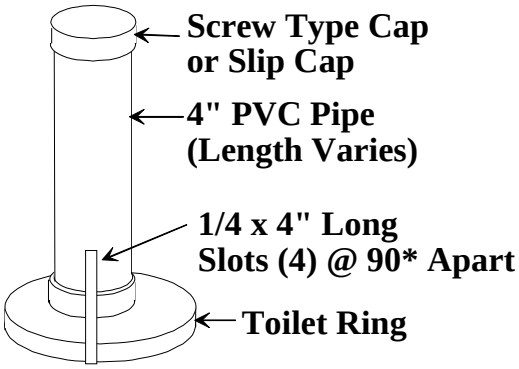
Pumpwells may be designed a variety of ways, but they must be constructed of concrete or plastic sewer pipe. A sufficient number and size of holes must exist in the pumpwell, at the level of the underdrain system, so that filtrate can flow into the pumpwell, from the underdrain void space, as rapidly as the filtrate is pumped out of the pumpwell. The pumpwell must be adequately supported on both sides of the synthetic membrane.

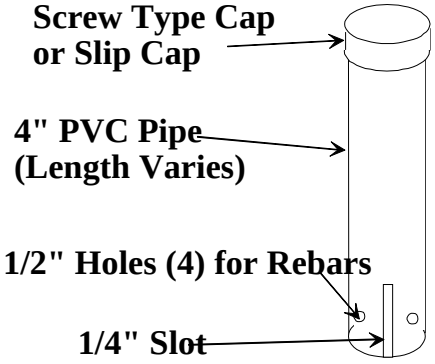


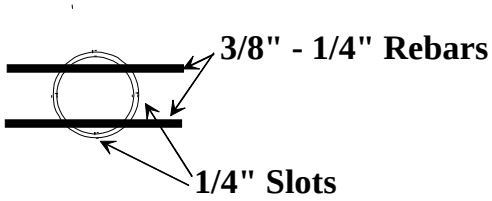
Typical Cross-section of a Pumpwell In A Synthetic Membrane-lined Intermittent Sand Filter

Appendix D--Inspection/Monitor Ports









END VIEW (BOTTOM)

Appendix E -- Disposal of Contaminated Filter Media

Whenever filter media is removed from a used filter, removing and disposing of contaminated filter media is to be done in a manner approved by the local health officer. Handle this material carefully, using adequate protective sanitation measures. Thoroughly wash hands and any other exposed skin with hot water and soap, following contact with contaminated sand filter media.

This material may be applied to the soil, according to the following, only when approved by the local health officer.

	APPLICATION	RESTRICTIONS/TIMETABLE
1.	Root crops, low-growing vegetables, fruits, berries used for human consumption.	Contaminated material must be stabilized and applied 12 months prior to planting.
2.	Forage and pasture crops for consumption by dairy cattle.	Forage and pasture crops not available until one month following application of stabilized material.
3.	Forage and pasture crops for consumption by non-dairy livestock.	Forage and pasture crops not available until two weeks following application of stabilized material.
4.	Orchards or other agricultural area where the material will not directly contact food products. Or where stabilized material has undergone further treatment, such as pathogen reduction or sterilization.	Less severe restrictions may be applicable.

Appendix F

Glossary of Terms -

Term	Meaning / Description
Alternative System	An on-site sewage system other than a conventional gravity system or conventional pressure distribution system. Properly and maintained alternative systems provide equivalent or enhanced treatment performance as compared to conventional gravity systems.
Approved List	"List of Approved Systems and Products", developed annually and maintained by the department and containing the following: (a) List of proprietary devices approved by the department; (b) List of specific systems meeting Treatment Standard 1 and Treatment Standard 2; (c) List of experimental systems approved by the department; (d) List of septic tanks, pump chambers, and holding tanks approved by the department.
Biological Oxygen Demand (BOD_5)	An index of the amount of oxygen that will be consumed by the decomposition of organic matter in a wastewater. This is the result of a laboratory analysis that consists of measuring the initial dissolved oxygen concentration, incubating the sample for five days at 68^o F, then measuring the final dissolved oxygen. The difference in dissolved oxygen concentration corrected for the initial dilution and sample volume is called the BOD_5. The BOD_5 test is one of the commonly used indicators of wastewater strength.
Coliform (Bacteria)	A group of bacteria that produce gas and ferment lactose, some of which are found in the intestinal tract of warm-blooded animals. They are indicators of potential ground water and/or surface water contamination with such fecal material.
Conventional Gravity System	An on-site sewage system consisting of a septic tank and a subsurface soil absorption system with gravity flow distribution of the effluent.
Conventional Pressure Distribution System	An on-site sewage system consisting of a septic tank and a subsurface soil absorption system with pressure distribution of the effluent.
Demand System	Any system where the dosing frequency (or flow to a treatment or disposal component) is controlled by the volume of effluent flowing to the component. For a demand system containing a pump and pressure distribution system, the pump turns on when sufficient volumes (demand) flow into the chamber causing the pump-on float to activate and the predetermined dose volume to be discharged to the treatment and / or disposal component which follows.
Disposal Component	A subsurface absorption system (SSAS) or other soil absorption system receiving septic tank or other pretreatment device and transmitting it into original, undisturbed soil.
Dosing Tank / Chamber	A tank which collects treated effluent and periodically discharges it into another treatment / disposal component, depending upon the needs and design of the particular on-site sewage system.
Drain Rock	Clean, washed gravel, varying in size from ¾ inch to 2 ½ inches.
Drainfield (Conventional)	An area in which perforated piping is laid in drain rock-packed trenches, or excavations (seepage beds) for the purpose of distributing the effluent from a wastewater treatment unit into original, undisturbed soil.
Effective Particle Size, $ES=D_{10}$	The diameter of the particle in a granular sample such as sand for which 10 percent of the total grains are smaller and 90 percent larger on a weight basis.
Effluent	Liquid which is discharged from an on-site sewage system component, such as a septic tank (septic tank effluent) or sand filter (sand filter effluent).
Excreta	Human urine and feces.
Experimental System	Any alternative system without design guidelines developed by the department or a proprietary device or method which has not yet been evaluated and approved by the department.
Failure	A condition of an on-site sewage system that threatens the public health by inadequately treating sewage or creating a potential for direct or indirect contact between sewage and the public. Examples of failure include: (a) sewage on the surface of the ground; (b) sewage backing up into a structure caused by slow absorption of septic tank effluent; (c) sewage leaking from a septic tank, pump chamber, holding tank, or collection system; (d) cesspool or seepage pits where evidence of ground water or surface water quality degradation exists; or

Term	Meaning / Description
	(e) inadequately treated effluent contaminating ground water or surface water. (f) Noncompliance with standards stipulated on the permit.
Fats, Oils & Greases (Fog)	FOG is a measure of the amount of fatty matter from animal and vegetable sources and hydrocarbons from petroleum products and waxes, such as from lotions, shampoos, and tanning oils. High levels of fats, oils and greases in the wastewater stream may interfere with wastewater treatment efficiency.
Fecal Coliform (Bacteria)	Coliform bacteria specifically originating from the intestines of warm-blooded animals, used as a potential indicator of ground water and/or surface water pollution.
Filter	A device or structure for removing suspended solid or colloidal material from wastewater.
Filter Media	The material through which wastewater is passed for the purpose of treatment (ASTM C-33).
Filtrate	Liquid which has passed through a filter.
Final Treatment/Disposal Unit	That portion of an on-site sewage system designed to provide final treatment and disposal of the effluent from a wastewater treatment unit, including, but not limited to, absorption fields (drainfields), sand mounds and sand-lined trenches.
Fineness Modulus	A numeric quantity to control the distribution of filter media particle sizes within the specified range for intermittent sand filters. It is calculated by adding the cumulative percentages of material in the sample retained on the 3/8 in., No. 4, No. 8, No. 16, No. 30, No. 50, and No. 100 sieves, and dividing the sum by 100.
Geomembrane	An essentially impermeable membrane used with foundation, soil, rock, earth or any other geotechnical engineering-related material as an integral part of a human-made project, structure, or system.
Geotextile	Any geotechnical engineering-related permeable textile used with foundations, soil, rock, earth, an integral part of a human-made project, structure, or system, and which serves to lessen the movement of fine soil particles.
Infiltrative Surface	In drainfields, the drain rock-original soil interface at the bottom of the trench; in mound systems, the gravel-mound sand and the sand-original soil interfaces; in sand-lined trenches/beds (sand filter), the gravel-sand interface and the sand-original soil interface at the bottom of the trench or bed.
Influent	Wastewater, partially or completely treated, or in its natural state (raw wastewater), flowing into a reservoir, tank, treatment unit, or disposal unit.
On-Site Sewage System	An integrated arrangement of components for a residence, building, industrial establishment or other places not connected to a public sewer system which: (a) Convey, store, treat, and/or provide subsurface soil treatment and disposal on the property where it originates, upon adjacent or nearby property; and (b) Includes piping, treatment devices, other accessories, and soil underlying the disposal component of the initial and reserve areas.
Particle Size	The diameter of a soil or sand particle, usually measured by sedimentation or sieving.
Percolation	The flow or trickling of a liquid downward through a contact or filtering medium. The liquid may or may not fill the pores of the medium.
Pressure Distribution	A system of small diameter pipes that apply effluent fairly uniformly over the entire absorption area, as described in the "Recommended Standards and Guidance for Pressure Distribution Systems" by the Washington State Department of Health. (See Conventional Pressure Distribution System.)
Proprietary Device Or Method	A device or method classified as an alternative system, or a component thereof, held under a patent, trademark or copyright.
Pump Chamber	A tank or compartment following the septic tank or other pretreatment process which contains a pump, floats and volume for storage of effluent. In timer-controlled pressure distribution systems, this is frequently called a "surge tank" or "equalization tank." If a siphon is used, in lieu of a pump, this is called a "siphon chamber."
Raw Wastewater	Wastewater before it receives any treatment.
Residential Sewage	Sewage having the consistency and strength typical of wastewater from domestic households.
Restrictive Layer	A stratum impeding the vertical movement of water, air, and growth of plant roots, such as hardpan, clay pan, fragipan, caliche, some compacted soils, bedrock and unstructured clay soils.
Routine Servicing	Servicing all system components as needed, including product manufacturer's requirements / recommendations for service.

Term	Meaning / Description
Sand Filter	A biological and physical wastewater treatment component consisting (generally) of an under drained bed of sand to which pre-treated effluent is periodically applied. Filtrate collected by the under drains is then disposed of by an approved soil absorption system. Pretreatment can be provided by a septic tank or another approved treatment component. An Intermittent Sand Filter is a sand filter in which pre-treated wastewater is applied periodically providing intermittent periods of wastewater application, followed by periods of drying and oxygenation of the filter bed. A Recirculating Sand (Gravel) Filter is a sand (gravel) filter which processes liquid waste by mixing filtrate with incoming septic tank effluent and recirculating it several times through the filter media before discharging to a final treatment/disposal unit. Sand-Lined Drainfield Trench is a combination of a pressure distribution drainfield and an intermittent sand filter consisting of a two-foot layer of intermittent sand filter media placed directly below the drain rock layer in the pressure distribution drainfield trench. A Bottomless Sand Filter is a special case of a sand-lined drainfield trench installed in a containment vessel and is usually used to utilize more suitable soils high in the soil profile for disposal.
Septic Tank	A water tight pretreatment receptacle receiving the discharge of sewage from a building sewer or sewers, designed and constructed to permit separation of settleable and floating solids from the liquid, detention and anaerobic/facultative digestion of the organic matter, prior to discharge of the liquid.
Service Interval	The time period between planned site visits to perform various system monitoring functions such as checking equipment, renewing depleted disinfectant chemical supply, collecting samples. The service intervals may be specified by contracts, operation plans, or local health jurisdiction permits.
Sewage	Any urine, feces, and the water carrying human wastes including kitchen, bath, and laundry wastes from residences, building, industrial establishments or other places. For the purposes of this document, “sewage” is generally synonymous with domestic wastewater. Also see "residential sewage."
Soil Type 1A	Very gravelly coarse sands or coarser, extremely gravelly soils.
Subsurface Soil Absorption System - “SSAS”	A system of trenches three feet or less in width, or beds between three feet and ten feet in width, containing distribution pipe within a layer of clean gravel designed and installed in original, undisturbed soil for the purpose of receiving effluent and transmitting it into the soil.
Suitable Soil	Original, undisturbed soil of types 1B through 6.
Synthetic Filter Fabric	See Geotextile.
Synthetic Membrane	See Geomembrane.
Timer-Controlled System	A pressure distribution system where the pump on and off times are preset, discrete time periods.
Total Suspended Solids (TSS)	Suspended solids refer to the dispersed particulate matter in a wastewater sample that may be retained by a filter medium. Suspended solids may include both settleable and unsettleable solids of both inorganic and organic origin. This parameter is widely used to monitor the performance of the various stages of wastewater treatment, often used in conjunction with BOD5 to describe wastewater strength. The test consists of filtering a known volume of sample through a weighed filter membrane that is then dried and re-weighed.
Treatment Component	A class of on-site sewage system components that modify and/or treat sewage or effluent prior to the effluent being transmitted to another treatment component or a disposal component. Treatment occurs by a variety of physical, chemical, and/or biological means. Constituents of sewage or effluent may be removed or reduced in concentrations.
Treatment Standard 1	A thirty-day average of less than 10 mg/l of BOD_5 and 10 mg/l of total suspended solids and a thirty-day geometric mean of less than 200 fecal coliform/100ml.
Treatment Standard 2	A thirty-day average of less than 10 mg/l of BOD_5 and 10 mg/l of total suspended solids and a thirty-day geometric mean of less than 800 fecal coliform/100ml.
Uniformity Coefficient, U_c	A numeric quantity which is calculated by dividing the size of the opening which will pass 60% of a sample by the size of the opening which will pass 10% of the sample on a weight basis. (symbolically $D_{60}/D_{10}=U_C$)
Vertical Separation	The depth of unsaturated, original, undisturbed soil of Soil types 1B - 6 between the bottom of a disposal component and the highest seasonal water table, a restrictive layer, or Soil Type 1A.
Wastewater	Water-carried human excreta and/or domestic waste from residences, buildings, industrial establishments or other facilities. (See sewage.)
Wastewater Design Flow	The volume of wastewater predicted to be generated by occupants of a structure. For residential

Term	Meaning / Description
	dwellings, this volume is calculated by multiplying the number of bedrooms by the estimated number of gallons per day (gpd), using either the minimum state design standard (120 gpd) or the locally established minimum standard (such as 150 gpd).
Wastewater Treatment Unit	A unit designed, constructed, and installed to stabilize liquid waste by biochemical and physical action.

Appendix G

Bibliography

A. Boyle, W.C. and Richard J. Otis, "On-Site Treatment", EPA Training Manual, Prepared for Environmental Research Information Center, ORD, USEPA, July 1979.

B. Converse, Matthew M., A Field Evaluation of Single Pass Sand Filters in a Northern Climate, Masters Degree Thesis, Master of Science, University of Wisconsin-Madison, 1999.

C. Design Manual: On-site Wastewater Treatment and Disposal Systems. U.S. EPA, EPA-625/1-80-012 October 1980

D. Final Report, Oregon On-site Experimental Systems Program, December 1982; Oregon Department of Environmental Quality

E. Glossary of Water and Wastewater Control Engineering; Joint Editorial Board of the AWWA, WPCF, ASCE, APHA, Copyright 1969

F. Gross, Mark A., Optimum Depth Of Sand For Filtering Septic Tank Effluent; Masters Degree Thesis, Master of Science, University Of Arkansas, 1981.

G. Gross, Mark, Dee T. Mitchell, Biological Virus Removal From Household Septic Tank Effluent; Proceedings of the Fourth National Symposium on Individual and Small Community Sewage Systems, ASAE, December 1984, New Orleans, Louisiana.

H. Gross, Mark, Ph.D., P.E., Dee Mitchell, Household Wastewater Virus Removal by Sand Filtration; 1988 Revision.

I. Hathaway, Randy J., Dee T. Mitchell, Sand Filtration of Septic Tank Effluent For All Seasons Disposal By Irrigation, Proceedings of the Fourth National Symposium on Individual and Small Community Sewage Systems, December 1984, New Orleans, Louisiana

J. Hines, Michael and R.E. Favreau, Recirculating Sand Filter: An Alternative to Traditional Sewage Absorption Systems, Proceedings of National Home Sewage Disposal Symposium, December 1974.

K. Koerner, Robert M., Ph.D., P.E., Designing with Geosynthethics, Prentice-Hall

L. Loudon, T.L., G.L. Birnie, Jr., Performance of Trenches Receiving Sand Filter Effluent in Slowly Permeable Soils, Proceedings of the 6th National Symposium on Individual and Small Community Sewage Systems, ASAE, December, 1991, Chicago, IL.

M. Management of Small Waste Flows, Final Report of the Small Scale Management Project, University of Wisconsin, EPA 600/2-78-173.

N. Mitchell, Dee, Sand Filtration of Septic Tank Effluent, Proceedings of the 5th Northwest On-site Wastewater Treatment Short Course, University of Washington, September 1985

O. Mitchell, Mike D. P.E., Writings, Northwest Septic, Inc., Mt. Vernon, Washington.

P. On the Performance of Experimental Sand Filters in the State of Oregon, Oregon Department of Environmental Quality.

Q. P. Otis, Richard, P.E., Soil Clogging: Mechanisms and Control, Proceedings of the 4th National Symposium on Individual and Small Community Sewage Systems, ASAE, December 1984, New Orleans, LA.

R. Otis, Richard J., P.E., On-site Wastewater Treatment Intermittent Sand Filters, Rural Systems Engineering, Madison, Wisconsin.

S. Sauer, D.K., W.C. Boyle, and Richard J. Otis. "Intermittent Sand Filtration." ASCE/EE, August 1976

T. Scherer, Billy P., Dee T. Mitchell, Individual Household Surface Disposal of Treated Wastewater Without Chlorination; Proceedings of the Third National Symposium on Individual and Small Community Sewage Treatment, December 1981, Chicago, Illinois.

U. Siegrist, Robert L., Hydraulic Loading Rates for Soil Absorption Systems Based on Wastewater Quality, Proceedings of the 5th National Symposium on Individual and Small Community Sewage Systems, ASAE, December 1987, Chicago, IL

V. Technology Assessment of Intermittent Sand Filters. U.S. EPA, Office of Municipal Pollution Control, Project Officer: James F. Kreissl. Authors: Damann L. Anderson, Robert L. Seigrist, Richard J. Otis.

X. Tyler, E. Jerry, James C. Converse, Soil Acceptance of Onsite Wastewater as Affected by Soil Morphology and Wastewater Quality, Proceedings of the 7th International Symposium on Individual and Small Community Sewage Systems, ASAE, December 1994, Atlanta, GA.